AAPG EXPLORER
GEOPHYSICAL CORNER

The Geophysical Corner is a regular column in the EXPLORER, edited by Bob A. Hardage, senior research scientist at the Bureau of Economic Geology, the University of Texas at Austin. This month's column, part two of a three-part series comparing structural and amplitude curvatures, deals with observing fault and fracture lineaments.

Euler Curvature Can Be a Calculated Success

By SATINDER CHOPRA and KURT J. MARFURT

Several (12, we think) types of seismic-based curvature attributes have been introduced the last few years – and of these, the most-positive and the most-negative curvatures described in last month's article are the most popular.

Most-positive and most-negative curvatures provide more continuous maps of faults and flexures than do maximum and minimum curvatures, because the latter tend to rapidly change algebraic sign at fault and flexure intersections.


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Other attributes, such as mean curvature, Gaussian curvature and shape index, also have been used by a few practitioners.

We describe here a technique called Euler curvature, which has valuable applications.

An attraction of Euler curvature is that it can be calculated in any desired azimuth across a 3-D volume to enhance the definition of specific lineaments. When this apparent curvature (the Euler curvature) is computed in several specific azimuths, the results are quite useful for interpreting azimuth-dependent structure.

The flow diagram in figure 1 explains the method for computing azimuth-dependent Euler curvature.

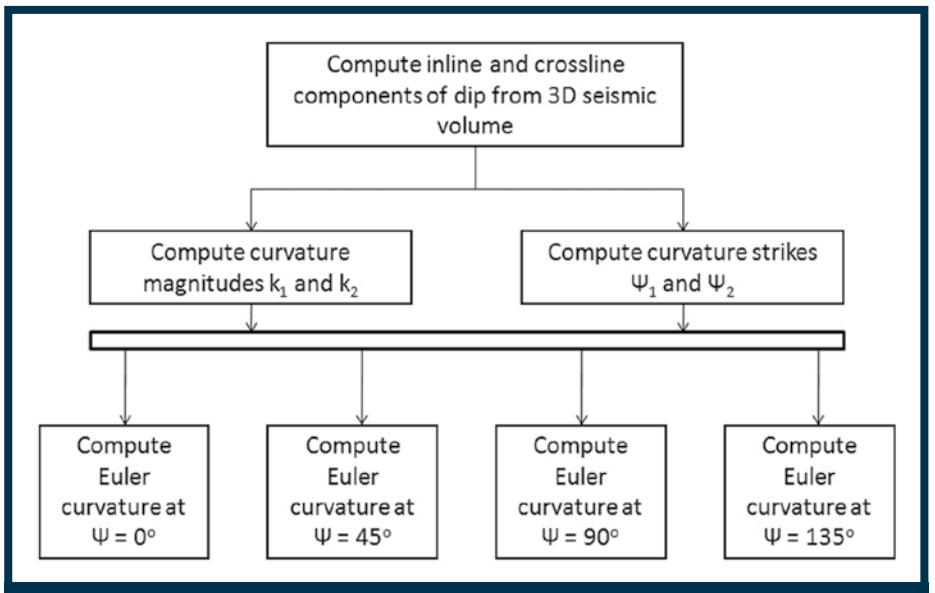

Figure 1 – Flow diagram showing the computation of Euler curvature.

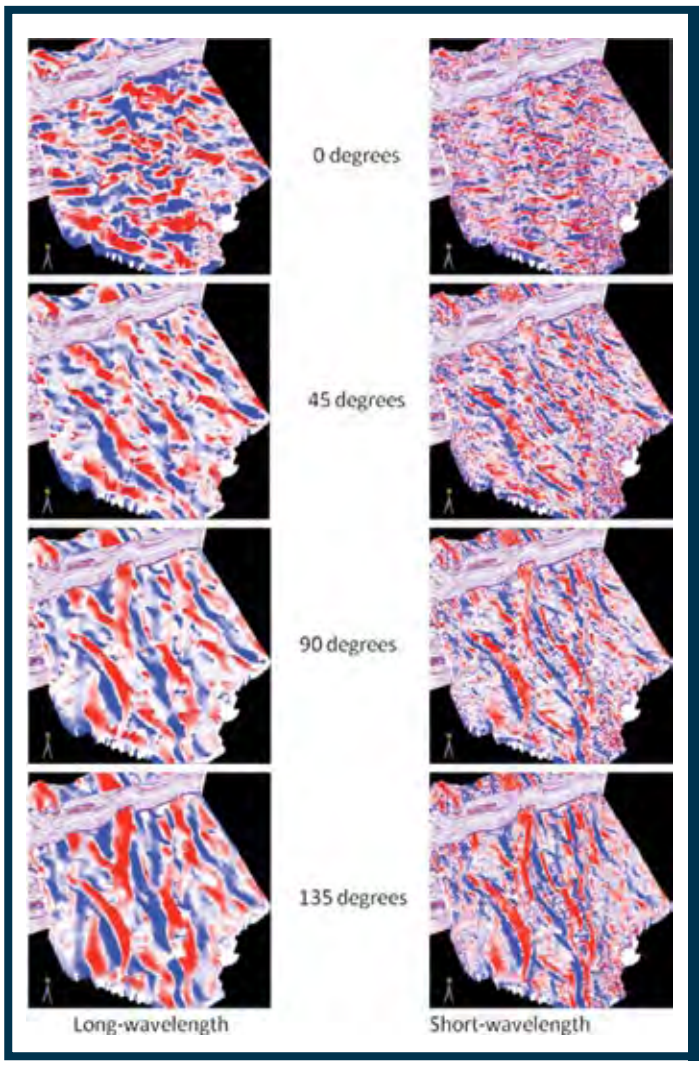

Figure 2 – Three-D chair views showing an inline vertical slice correlated with a suite of Euler-curvature volumes calculated at different azimuths. Azimuths are labeled in the center column. (Left) Long-wavelength estimates. (Right) Short-wavelength estimates.

Applications

Mapping the intensities of fracture sets has been a major objective of reflection seismologists. Curvature, acoustic impedance and reflection coherence currently are the most effective attributes used to predict fractures in post-stack seismic data.

We describe here the application of Euler curvature to a 3-D seismic volume from northeast British Columbia, Canada. We use an interactive workflow to utilize Euler curvature much as we do in generating a suite of shaded relief maps.

Figure 2 shows 3-D chair displays through volumes of Euler curvature calculated at azimuths of 0, 45, 90 and 135 degrees from north. The left column shows long-wavelength curvature calculations, and the right column displays short-wavelength calculations.

Notice how east-west lineaments stand out when north-south curvature is estimated (azimuth = 0):

- When curvature is estimated in an azimuth of 45 degrees, northwest-southeast lineaments are pronounced.
- When east-west curvature is calculated (azimuth = 90 degrees), north-south features events are emphasized.
- When northwest-southeast curvature is estimated (azimuth = 135 degrees), events slightly inclined away from north-south are better defined.

The analysis area shown in these figures spans approximately 100 square kilometers.

As emphasized in last month's article, short-wavelength displays show more lineament detail and resolution than do long-wavelength displays. That principle is illustrated again by the displays in figure 2.

The important concept presented here is that there are obvious advantages in calculating Euler curvature on post-stack seismic volumes, because azimuth directions of curvature can be chosen to highlight lineaments in preferred directions.

Conclusions

Euler curvatures calculated in desired azimuthal directions produce better definitions of targeted lineaments.

Depending on the desired level of detail, either long- wavelength or short-wavelength estimates can be calculated. Short-wavelength Euler curvature would be more beneficial for observing fracture lineaments.

This work is in progress, and we hope to calibrate seismic-based lineaments determined with this technology with lineaments interpreted from image logs.

Acknowledgments

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(Editor's note: AAPG member Satinder Chopra is with Arcis Corp., Calgary, Canada, and AAPG member Kurt J. Marfurt is with the University of Oklahoma, Norman, Okla.)

Ecopetrol

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nation of five years of oil production and refinery profits from 1946 to 1951 – and also whether the concession could be extended at the end of the 30-year term.

In 1941 the government notified Tropical Oil Co. that its concession rights would end on Aug. 25, 1946.

The company rejected the decision – and facing an impasse, the government requested the Supreme Court settle the issue.

In 1944, the Supreme Court ruled – in a controversial decision – that the expiration date of the contract was Aug. 25, 1951, and that on that date all the reserves, assets, equipment and the refinery would revert to the nation.

The court's decision left the government in a quandary, however, as to what to do with the concession at the moment of its reversion. Hence, the government in 1944 created the National Petroleum Council, a technical advisory entity attached to the Ministry of Petroleum, which began exploring options to manage the concession: private company, JV between the government and private investors, and state oil company.

After failed efforts to find private investors – both Colombian and foreign – the Colombian government created Ecopetrol on Jan. 9, 1951. After long and difficult negotiations the government signed a contract by which International Petroleum Colombia (an affiliate of today's ExxonMobil) provided technical assistance in running and managing the field for three years and for the upgrading of the Barrancabermeja refinery for another 10 years.

The refinery finally reverted to the state in 1961.

Corollary

Starting from humble origins 60 years ago as the administrator of the La Cira-Infantas field, Ecopetrol today is a modern petroleum corporation. It is Colombia's largest oil and gas company, accounting for about 60 percent of the country's total production.

It is the fourth largest company in Latin America and one of the top 40 oil companies in the world.

It is involved in upstream activities in Brazil, Peru and the U.S. Gulf Coast. It also owns the main refineries in Colombia, most of the network of oil and products pipelines, petrochemical plants and is now entering into the bio fuel business – and it has set itself a production target for 2015 of 1.3 million BOPD.

Breaking with the traditional Latin American state oil company mold, Ecopetrol has been partially privatized. It is listed on the NYSE and on the Toronto, Lima and Bogota stock exchanges, and about half a million Colombians now own shares in it.

(Editor's note: Miguel Ramirez is president of the AAPG Latin America Region, Victor Ramirez is the Region's president-elect.)